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THE TREATMENT OF CHRONIC EMPYEMA*

BY CARL A. HEDBLOM, M.D.
OF ROCHESTER, MINN.

Definition.—The word empyema is from the Greek signifying a collection of pus in a cavity. This was the sense in which the word was used by Hippocrates, Galen, Ætius, and others. Ætius, in fact, defined the term much as it would be defined to-day: he stated that those persons are called "empyici" in whom an abscess in any part of the pleura has ruptured into the pleural cavity. Aretæus *Cappadox* wrote: "Those persons in whose cavities above, along the region of the chest, or in those below the diaphragm, abscesses of matter form, if they bring it up they are said to be affected with empyema, but if the matter pass downwards they are said to labor under Apostemes." Later, Cælius *Aurelianus* and others called a collection of fluid anywhere in the body empyema. Guy de Chauliac, 1363, defined the word as follows: "Empyma or empyema in Greek signifies a collection of pus in whatsoever part of the body it may be, but more properly used meaning a collection of suppurative matter in the testes, thorax, or abdomen. In a more restricted sense it means pus in the thorax: this is the most proper and common significance. Following it one calls those who have pus in the thorax 'empyes' or 'empyiques' in Greek, and suppurants or purulents in Latin."

Later a difference of opinion developed as to whether the term empyema should be limited to collections of pus or what other effusions should also be included. Boerhaave wrote: "Whenever there is a collection of pus between the lungs and the pleura in the cavity of the chest it is called an empyema." De Sauvages, Cullen, and others, restricted the term to pus only. Kisnerus also wrote that when the fluid is not pus but serous (aquosa simplex) it should be called hydrops of the chest. It was argued by others, on the contrary, that what was blood in the thorax may have changed to pus and that therefore collections of fluid of any kind and collections of air should be included.

The drainage operation was also called "empyema" (Dictionnaire des Sciences médicales). The expression "the operation of empyema was performed" was of frequent occurrence.

Leonus *Lunensis* (Dominicus), 1597, used "empyemate" and "puru-

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Columbia University

lentia " as synonymous for fluid occupying sometimes all, sometimes part, of the empty cavity of the thorax (cavitate vacua pectoris).

In the modern use of the term the word may still be defined as a collection of pus in the pleural cavity, although an interlobar empyema might be construed to fall outside this definition. In the transitional stage between acute empyema and a preceding serous effusion the distinction is a matter of definition. In the chronic condition the effusion is always frankly purulent.

It is also difficult to make an inclusive definition of what constitutes chronicity. Certain types of empyema, those with large bronchial fistulas, those with cavities at the apex, and some of uncertain duration at the time they were first recognized are often potentially chronic from the onset, in the sense that they do not progress to a cure by simple drainage treatment. Perhaps the most generally accepted criterion of chronicity, however, is the duration of the process. A great many writers consider an empyema of six weeks' duration to be chronic. For the purpose of this discussion, with the exceptions noted, three months are taken as the time limit between the acute and chronic condition.

HISTORICAL REVIEW

The history of empyema up to the last three decades is essentially that of chronic empyema. To what ancient period its recognition and drainage treatment date we do not know. It seems probable that incision for drainage of empyema necessitas was done by the Chinese and Egyptians. The earliest known direct references to the condition, now extant, are those of Hippocrates. His teachings as to etiology, symptomatology, prognosis, and treatment contain much that is fundamental to our present-day conception. The symptoms and signs, as he stated them, were pain in the chest, high fever, cough, distress when attempting to lie on the sound side, and œdema of the feet and of the eyes. After an illness of fifteen days the patient was examined for fluid. This examination consisted of shaking him by the shoulders and diagnosing the presence and site of fluid by the splash. If no splash could be elicited the side in which the pain and swelling was most marked was considered the one affected. Hippocrates taught that the matter should be let out either by knife or cautery. If there was a swelling externally, he directed that an opening should be made in it, if not, the opening should be made at the level of the third rib from the last, and rather behind than in front. He made the incision superficially with a large bistoury, then continued with a lancet wrapped in linen, the point only being free, or used a trocar or trephine or the cautery throughout. After some of the pus had been let out he closed the opening with a tent of lint attached to a thread. Every day it was removed and pus evacuated. On the tenth day he injected warm wine and oil. When the discharge became clear and glairy, he introduced into the opening a hollow metal tube.

He observed that patients who became affected with empyema after

pleurisy recovered if they got clear of it in forty days after the time it ruptured; but if not, it passed into phthisis. As to prognosis he stated that if pure and white pus flowed when empyema was treated either by cautery or incision, the patient recovered; but if the pus was mixed with blood and was stringy and fetid, he died.

Euryphon, a contemporary of Hippocrates, treated empyema with the actual cautery. Celsus, who practised at the beginning of the Christian era, is the author of our next most ancient reference. He wrote on the symptomatology and prognosis much as did Hippocrates. He stated: "'Tis common for fistulæ to extend beneath the ribs. When this case occurs, the ribs in that part must be cut through on both sides and taken out lest anything corrupt be left within," and, "Fistulæ of the chest are very difficult of treatment, so that sometimes physician, sometimes patient, giving up hope, leaves the case to Nature herself."

Pliny related the story of a soldier with empyema whose life was despaired of by his physician. Seeking relief by death in battle, he was wounded in the thorax; the pus escaped and he recovered.

Leonidas *Alexandrinus,* a Roman physician of the second century, recommended the actual cautery for effecting drainage. He remarked that his contemporaries feared less to open the chest by the cautery than by the knife.

Aretæus *Cappadox,* of uncertain date, probably a contemporary of Galen, said concerning the pathology of empyema: "It is a wonder how from a thin, slender membrane having no depth, like that which lines the chest, so much pus should flow; for in many cases there is a great collection. The cause is an inflammation from redundancy of blood, by which the membrane is thickened; but from much blood much pus is formed immediately. But if it be determined inwards, the ribs being the bones in that region * * * I have said above that another species of phthisis would naturally occur. But if it points outward the bones are separated, for the top of the abscess is raised in one of the intercostal spaces, when the ribs are pushed to this side or that."

Cælius *Aurelianus,* who lived in the early part of the fifth century, according to Haller a contemporary of Leonidas, wrote on abscess and empyema. Buck credits him with being familiar with ascultation of the chest.

Galen in his writings emphasized the importance of providing for the escape of pus in the thorax in order to avoid the ravages, especially of phthisis, of which it might be the cause. He removed portions of carious ribs, injected warm wine into the cavity (pectore), and urged the patient to cough while leaning toward the affected side. If the pus and injected fluid did not thus escape, aspiration was done.

Two Greek physicians of the early middle ages who wrote on empyema are Ætius and Paulus Ægineta. Ætius, besides giving a very clear definition of the pathologic condition, stated that in certain cases empyema is formed without fever. He approved of the cautery in its treatment.

Paulus Ægineta wrote a compend of medicine which later was translated into Arabic and Latin. His writings on empyema were based on the teachings of Hippocrates and Galen but showed some originality. He is quoted by Marcellus Donatus to the effect that cautery or incision of the thorax, by allowing vitality to flow out with pus, causes immediate death or an incurable fisula results.

During the latter part of the middle ages some of the earlier medical literature was preserved by the Arabs. Their most notable contributor to surgical literature was Albucasis. He recommended incision or cautery operation for drainage of empyema. Avicenna and Avenzoar also approved of paracentesis and the cautery. Zacchias, however, said that the Arabian physicians feared the operation for empyema. Lelorraine said that the Arabs disagreed as to the advisability of operation. Nicolaus Massa, while granting that incurable fistulæ might be left after operation, maintained that a fistula is vastly better than certain death. He recorded a case of draining sinus following a stab wound that closed after seven years. He cited the case of a girl who for six days coughed up eight pounds of pus daily, and ultimately recovered.

Guy de Chauliac, besides giving a definition of empyema which very closely agrees with our present conception of the disease, mentioned that the operation was performed by his contemporaries.

Smetius, 1574, reported a case of empyema following a dagger wound of the thorax. An incision was made between the tenth and eleventh ribs and much foul pus was evacuated. The cavity was then irrigated with honey and water.

Vesalius taught that incision should always be made for empyema and that no one should die of the disease. Certain persons would die because of their wounds and not because of the operation. He referred to several cases in which he operated successfully. He wrote also on thoracic fistulæ.

Amatus *Lusitanus* was one of the first of a considerable number of physicians of the Renaissance period who wrote on empyema. His is also one of the most original and independent expositions on the subject. He outlined in detail the teachings of Hippocrates on the treatment of empyema and discussed the relative advantages of the incision and the cautery. With regard to the site for drainage, he pointed out that Hippocrates ordered that the drainage should be made as near as possible to the septum transversum (diaphragm) without injuring it. As to which interspace this should be, he said that rather than rely on the authority of Hippocrates, he determined it for himself on the cadaver. He wrote:

"At one time a brother of Andreas Vesalius, the renowned anatomist, in my presence was carefully cutting up a human body. Snatching the knife with which the excellent youth was dissecting, I made an opening between the second and third ribs on the left side, and after the knife itself had been thrust in I discovered that the 'septum transversum' could draw no harm from it. However, the mad-

ness of physicians reaches this point that they do not cut between the second and third ribs (counting from below), but rather between the fourth and fifth, or if it pleases the gods, between the fifth and sixth, although they cannot draw the corrupt matter easily without loss of the patient, since the pus is held in a bag and they cannot do away with it even when the legs are raised and the head is hanging down."

He cited a successful case in which he drained between the third and fourth ribs.

Marcellus Donatus had a case of empyema necessitas that progressed to a spontaneous cure; he remarked that almost all empyema patients and many suffering from a wound penetrating into the chest died because physicians feared to cut in the right region, an operation which he advised. However, if pus would not drain through the mouth, he believed that the opening should be made between the third and fourth ribs (counting from below) rather than lower down, on account of the danger of injury to the diaphragm. He added that the incision should be made wherever pus had collected, and cited many authorities for the statement that pus might drain through the urine. He spoke also of perforation of the diaphragm by the abscess.

Leonus *Lunensis* (Dominicus) gave detailed directions for the medical treatment, internal and external, and referred briefly to the use of incision and cautery in cases not cured by such treatment.

Castellus, in his treatise on the diseases of the thorax, discussed at great length the external and surgical treatment, but did not add anything original.

Fabricius *ab Aquapendente* systematically discussed the subject and described the instruments used by Hippocrates and by Paulus Ægineta. He stated that most persons who had received a penetrating wound in the thorax had to wear a silver tube for life and that he knew of patients who had carried tubes for twenty or thirty years. Fistulæ persist, he wrote, because of the constant motion of the chest, because the pleura is sinewy and bloodless, and because of the tortuous course of the fistulous tract. To avoid the motion, patients should be in bed and refrain from work and all speech, from wrath, and any repressed breathing whatsoever; second, the hard skin of the fistula should be removed either by softening or corroding or burning or by drug or by instrument. The pleural cavity could also be closed by the scar. Furthermore, all corruption must be removed and the fistulous tract straightened by cutting the curves with a knife. Fabricius thought that the rib resection operations recommended by Celsus were very difficult, dangerous, and cruel. He was of the opinion that a rib could not be removed without tearing the pleura and so causing the death of the patient. He recommended a curved silver drainage tube and treatment of the fistula as though it were a spring and not an ulcer.

Zacutus *Lusitanus* published records of three cases. In the first, pus drained by the urine; in the second, in which there was much purulent

sputum, the patient recovered spontaneously on a milk diet; in the third, after great fear and misgiving as to the result should operation be undertaken, it was decided to be guided by the dictum of the "old man" (oraculum senis). An incision was made and the patient recovered.

Cases were reported by Horstius, by Tulp, and by Jalon, in which pus is said to have drained by the urine, and in Tulp's case, also by the umbilicus. Cures following operations were described by Kisnerus and Riedlinus. Operative treatment was discussed by Zacchias, Camerarius, Scultetus, Fienus, and Fliccius. Scultetus' article is the earliest accessible reference in the French. He discusses indications, time, site, technic, and instruments to be used in the operation of paracentesis. He stated that the "temperament" of the air must be considered and cited Hippocrates' recommendation that the winter and summer should be avoided if possible on account of the sudden changes in the air at these seasons. He also mentioned that a purulent effusion is in need of earlier drainage than a hydrops on account of the rapid increase in amount and the ulceration produced by the latter. He believed that of all sites for drainage the seventh interspace, recommended by Hippocrates, is the best because it furnishes the most dependent drainage. He recommended injections of wine and oil after operation.

Fienus wrote on paracentesis for empyema. This is the earliest available article in the German. He defined paracentesis as a cut through which an opening is made into the body cavity (Hole des Leibes) whether by a cold iron or cautery. He discussed in a most interesting manner the problems involved in pneumothorax produced by this operation.

Fliccius, after citing the authorities with regard to suitable location for drainage, decided that the best place is between the fifth and sixth ribs. Kisnerus wrote that venesection, generally a most excellent remedy, is almost supreme in cases of empyema.

Kinner refers to blistering (ustiones) and cites Ætius, who directed that empyema patients should be burned about the neck, back, and sides in eight places in all. Kinner stated that this treatment should be shuddered at and that it was easy to believe Ætius was made a physician from a hangman or a tormentor rather than from a goldsmith.

Wilhelm ten Rhyne is quoted by Riedlinus as stating that Japanese surgeons inserted the leaves of India fig trees in empyema patients.

The available literature from the eighteenth century is essentially a repetition of the foregoing; that is, citation and discussion of authorities and a few isolated case reports. Ingram is the author of the earliest available treatise in the English. He reported a case successfully drained and took issue with Sharp, who in his "Operations of Surgery," Chapter XXIV, says that the operation "should be discarded as unnecessary when blood or matter is fluctuating in the thorax," and confines the necessity of it to "cases of water." A few other successfully operated cases were recorded by Springsfeld, Valentin, Gädücke, Carboué, and

others. Koelpin reported a case of pulsating empyema proved at operation. A few spontaneous cures and many post-mortem findings are recorded by Warner, Fürst, and Morin.

Lapeyre said that while the operation for empyema is known to all persons of the art, it is rarely practised because of the uncertainty of diagnosis and lack of assurance as to success of the operation. He believed, however, that the operation should be done oftener. He reported one case of empyema pointing in the chest wall which was opened and drained.

The greatest impetus to advance in surgery of the thorax since Hippocrates was the marked improvement in diagnosis by the art of percussion of the thorax described by Auenbrugger in 1761. It was only after several decades, however, that this new method was appreciated. The great clinician, van Swieten, who was Auenbrugger's teacher, ignored it. Stoll was the first to mention its great value in detecting pleurisy and especially empyema, in order that operation might be performed. Corvisart and Laennec[106] were among the first outside of Vienna to emphasize its importance. Corvisart translated Auenbrugger's treatise into the French.

The literature of the first eight decades of the nineteenth century is full of discordant notes with regard to the treatment and citations of patients with empyema necessitas. In some cases the cavities ruptured spontaneously; others were opened by simple incision. A great number of necropsy protocols were published.

Hourelle, 1808, wrote that in the advanced stages of empyema, internal medication is at best useless and that blistering, scarification, and fomentations are not much better. He stated that the danger is not in operation, but in the difficulty of applying it with certainty.

Burin d'Aissard stated that the operation had been feared because of the misapprehension that air in the chest will almost always kill the patient. He was of the opinion that when a fistula results it should be left to time and a good regimen.

The pessimistic note is again sounded in 1825 by Dumont, who said that there is always a possibility of cure by spontaneous absorption, by thickening of the pleura, by sclerosis, by absorption by way of the urine and bowels, or by absorption into the blood. He recommended mercury, purgatives, bleeding, and a rigid diet. He added that the most common termination is death.

Rullier, in speaking of the difficulties of diagnosis, points out that Dionis, Baffos, and Corvisart all opened the chest without finding pus and that several of their patients died.

Putegnat laid down as indication for operation acute and chronic dyspnœa, local and general œdema, and emaciation, for the relief of which all medical remedies had failed.

Colson, writing on empyema following a perforated wound of the thorax, mentioned the professional " sucer " present at every duel ready to draw out the blood from the wound. So successful was this treatment that it was thought to be of the devil; and in one case a priest refused the last sacrament to a wounded man thus treated. Bache states that the cause of chronic empyema is the failure of lung expansion.

In 1834 Faure reported before the Academy of Medicine in Paris a series of eight cases in which operation had been performed. Two patients were cured and all the others improved. This report precipitated a prolonged discussion, for many physicians held operation in disfavor. Thus Barlow stated that Andral and Louis regarded empyema as necessarily fatal. Laennec is quoted as saying that the operation for empyema is rarely successful. Of fifty patients treated by Dupuytren, only four were cured. When he himself developed empyema he refused operation and is quoted as having said that he would die at the hand of God rather than with the help of the surgeon.

The unsatisfactory status of the treatment of purulent pleural effusions is strikingly reflected in results obtained. The greater number of case reports up to 1834 were those of empyema necessitas; some patients recovered spontaneously after draining (Malin and Salomon, Shortridge, Steinheim), others after incision (Heyser, Claessens, Cleland, and Tourtuel). A few cases were recognized and treated before the chest wall was perforated (Colegrove, Martini, Wolfly). A large number of operated cases ended fatally (Kilgour, Cayol, Bonnet, and many others). Small series of cases were reported by Chambers, Oke, Hartshorne, Niese, and in 1841 a series of forty-three collected cases by Sédillot.

Colson, 1876, stated that the use of syringes, cannulas, and other aspirating devices employed by Dionis, Anel, Scultetus, Bruer, and others, had fallen into disfavor. After the work of Bowditch, in 1852, the aspiration method again came into vogue.

Gimbert reported a case in which seventy-four aspirations and lavages were done, followed by a cure. Bouchut, in 1872, told of one patient tapped fifty-eight times during sixteen months and another one hundred and twenty-two times during eleven months. In one instance 50 gallons of " matter " is said to have been aspirated during four and one-half years without any diminution in the daily amount. Simmonds found that in forty-eight collected cases treated by aspiration forty-two were unimproved.

Although the ancients, following Hippocrates' teachings, probably diagnosed and operated in many cases of empyema in the acute stage, the later operative treatment was largely for empyema pointing in the chest wall. Besides the cutting and cautery operation the use of caustic stone was also described. Some practised burning a deep hole and palpating the bottom of it for pus. In 1810 Aupepin described a " new " technic for performing thoracotomy by making the opening in the skin and intercostal tissue at slightly different levels. The valve-like arrangement so

produced was designed to prevent pneumothorax after the withdrawal of the aspiration tube.

In 1881 Homén published a series of ninety-one collected cases of patients treated by incision and published by seven different authors between 1868 and 1876. Of this group, 47.25 per cent. of patients were cured, 23.08 per cent. had residual fistulas, and 29.67 per cent. died. Fifty per cent of 52 of these patients who had irrigation in addition to incision were cured, 17.31 per cent. developed fistulas, and 32.69 per cent. died. In a larger series of 141 patients the mortality was 33.33 per cent.

Rib Resection for Drainage.—Rib resection in empyema is mentioned by Galen, who states that he removed pieces of rib that were necrosed in a case of empyema necessitas. By other physicians they were cauterized, removed, or let alone. No mention is found of resection of a sound rib until 1860, when Walter resected the eighth rib for drainage of a chronic empyema caused by a knife stab between the ribs. The fibrous membrane was removed with finger and spatula. "The cavity was so large as readily to admit the head of a child a year old." The cavity was washed with tincture of iodine, zinc sulphate, and decoctions such as of white oak bark. The chest wall retracted and the cavity was completely obliterated in the course of a year. Roser is said to have been the first to propose resection, but it was not until 1865 that he performed the operation. Peyrot, Billroth, Fraentzel, Koenig, Ewald, and others, were among the first to perform the operation. Weissenborn, 1876, reported a series of five cases.

Plastic Operation for Obliteration of Chronic Cavities.—According to Peitavy, Simon first recommended rib resection in order artificially to reduce the size of the cavity in chronic empyema. Peitavy published the case in which Simon made the observation that the cut ends of the resected ribs approximated. Simon taught this idea in his clinic in 1869. Heineke first published these observations in 1872, in his "Compendium der Chirurgischen Operations und Verbandlehre." Küster, in 1877, wrote that in chronic cases he resected one or two ribs in front of and behind the fistula. Létiévant reported a cure in a chronic case and emphasized the fact that not only drainage but collapse of the cavity was promoted by rib resection.

To Estlander, however, is generally accorded the credit of having directed attention to the principle of multiple rib resection for obliteration of chronic cavities. He resected a sufficient number of ribs completely to unroof the cavity. In his first communication,[63] in 1879, he reported six cases. In a later report[64] he emphasized that each case should be dealt with according to the condition found and that in cases with large cavities it might be necessary to repeat the operation a second or even a third time. Five of his eight patients were cured, two died, and one was still convalescing at the time he wrote.

Gallet collected the first 100 cases in which operation was performed

by the Estlander method. In 9 of the 18 patients who died, necropsy showed large cavities with collapsed lungs. Voswinckel reported the results in 129 collected and 6 personal cases of multiple rib resection. Fifty-six per cent. of these patients were cured; 20 per cent. had improved; 4 per cent. were not improved; and 20 per cent. had died. In one case the results were uncertain. Of 14 tuberculous patients included in this series, 8 died, 2 were cured, 3 improved, and 1 did not improve.

The plastic operation was variously modified. Resection of segments of the ribs at the borders of the cavity through parallel incisions was made by Tietze and others. Wilms strongly advocates this method, especially for tuberculous empyema. He calls it the "Pfeiler Resection." Jaboulay and Leymarie resected the sternal ends, and Boiffin[22] the vertebral ends of the ribs. Tietze resected the ribs as for a Schede operation, but instead of excising the pleura, tamponed it against the lung. He stated that it produces a concentric pull on the lung and diaphragm.

In 1890 Schede described the extensive resection that bears his name. After turning up a skin and muscle flap of larger extent than the cavity, the whole of the chest wall underneath was resected, the skin muscle flap being then allowed to fall against the collapsed lung. He stated that in case the cavity extends to the pleural dome, it is also necessary to resect the first rib. He reported 10 cases with 2 deaths, and later 389 collected cases with 87.7 per cent. cures and 12.3 per cent. mortality. Bergeat collected 134 cases in which 56.5 per cent. of the patients were cured; 4.5 per cent. were improved; 14.3 per cent. had residual fistulas; 1.5 per cent. were not improved, and 23.2 per cent. died. Sudeck, Depage, Beck, Helferich, Friedrich, Sauerbruch,[156] and others, attempted to lessen the duration and shock of this formidable operation by dividing it into stages by various modifications. Sudeck, Depage, Friedrich, and later Melchior and Goebel made use of the thickened parietal pleura to help in obliterating the cavity.

In 1892 Delorme enunciated a new principle in the treatment of chronic empyema cavities, namely, that of their obliteration by reëxpansion of the lung. Previous to this time attention had been consistently centred on the chest wall, the collapse of which was considered the only means of obliterating the cavity. This new method was foreshadowed by Cornil, Oulmont, Ehrmann, and others. In several post-mortem cases in which the empyema had been of three months' to a year's duration, Oulmont was able to double or treble the size of the collapsed lung by gentle insufflation. Laennec[107] also expressed the opinion that the reason the lung remained collapsed in these cases is because of the limiting membranes and not because of the condition of the lung. Others, on the contrary, were of the opinion that sclerosis in the lung tissue or inseparable adhesions on its surface preclude any possibility of reëxpansion of the lung. It remained for Fowler and Delorme to prove the point on the living patient. Fowler performed his first operation October 7, 1893, and

reported the case December 30th, of the same year. He considered the operation adapted to non-tuberculous cases, and concluded the article as follows: "The case suggests a method of dealing with some of the instances of old empyema with persistent sinus which resist all means usually employed for their cure."

In May, 1892, Delorme dissected off the parietal pleura more than 1 cm. thick in a patient with a small empyema cavity. The expansion of the lung that resulted suggested to him the possibility of obliterating large cavities by a similar procedure. In June of the same year (1892), before the Academy of Medicine, and in April, 1893, at the Surgical Congress, he proposed the method. January 20, 1894, Delorme first performed the operation in a case of empyema of four and one-half months' duration, and obtained complete expansion of the lung. To Delorme, therefore, belongs the credit of first having enunciated the principle and to Fowler the credit of first having performed the operation. In 1896 Delorme published the results in 18 cases; 5 patients were completely cured; 2 were improved; and 8 were not benefited. Delorme recognized no contraindication to operation except a poor general condition of the patient. He wrote that tuberculosis is not a contraindication, but that in its presence it is almost impossible to secure complete obliteration of the cavity.

Modifications of the decortication operation as first described by Delorme and Fowler have been numerous. The most important one designed to conserve the chest wall was the introduction of rib-spreading exposure. Roux found that by retracting at the anterior angle of an intercostal incision good exposure was secured. Sauerbruch[157] described an improved technic with subsequent suture around the ribs for air-tight closure. Friedrich and others have used rib retraction. Lilienthal[118] sectioned the ribs in addition to spreading them. Boiffin[23] used a posterior incision to secure access to the paravertebral space. Quénu and Soubottin sectioned the entire thickness of the chest wall anteriorly and posteriorly, but without removing the ribs. Krause, Jordan, Goullioud, and others did extensive resection, practically combining the Estlander and Delorme operations. Ringel and others combined the Schede and Delorme procedures. After decortication Lambotte proposed insufflation of the lung through a preliminary tracheotomy.

Successful case reports have been published by Bazy, Battle, Newton, Cotte, Meyer, and Kümmell. Lund reported seven cases with two deaths, neither due to shock. Mayo and Beckman reported seven cases, with one death. They expressed the opinion that the operation has not received the consideration it deserves. Dowd reported fifteen cases; fourteen of them were in children whose average age was five and one-half years. There was one operative death. Dowd wrote that in extreme cases there are many disappointments and that it is easier to secure expansion of the lung than to maintain it. Lilienthal[117] reported twenty cases with three

deaths, Whittemore fifteen cases with eleven complete cures and no mortality. In twenty-nine cases mentioned by Binnie, seventeen patients were cured; nine were not improved, and three died. Violet collected seventy-nine cases. Forty-eight and one-tenth per cent. of the patients were cured; 7.7 per cent. were improved; 31.7 per cent. were not improved, and 11.4 per cent. died. One case was not completed. Kurpjuweit reported fifty-six collected cases. Thirty five and seven-tenths per cent. of the patients were cured; 19.7 per cent. were improved; 33.9 per cent. were not improved, and 10.7 per cent. died.

In a case in which it was impossible to separate the thickened pleura from the lung, Ransohoff found that by making gridiron incisions about 0.6 cm. apart, a considerable expansion of the lung was obtained owing to wide separation of the cut edges of the pleura. This procedure has been used since quite extensively in conjunction with the various modifications of the plastic operations.

Lambotte recommended suturing the lung to the parietal pleura after decortication, if the lung failed to expand.

Kurpjuweit advised extensive rib resection to bring about expansion.

Souligoux proposed cutting the thickened membrane at its reflection to the parietal pleura, thus securing mobilization *en masse* if the lung failed to expand. The method appears to be practical, however, only if the lung also expands at least in part.

Robinson described a plastic operation for closure of chronic cavities posteriorly, making use of the muscles of the thoracic wall to help fill the cavity. Taddei obliterated a cavity by transplanting a lipoma. Beck obtained very good results by the use of skin flaps after radical excision of the roof of the cavity. He has also reported 80 per cent. of patients cured in 150 cases of chronic empyema sinuses in which bismuth paste was used.

Irrigation of Chronic Cavities.—The use of irrigation for chronic cavities dates back to Hippocrates. He directed that wine and oil should be injected on the tenth day. Galen and Rhazes, the Arabian, used water and honey. Guy de Chauliac employed various decoctions. Evacuants and detergents were used by Fabricius ab Aquapendente, Ambrose Paré, Dionis, Willis, and others.

Lamotte, according to Massiani, was the first to reject all irrigations. Opinions have differed on the subject ever since. Van Swieten, Ravaton, Maraud, and Pelletan used various fluids. Bell, Chopart, Desault, and Lassus condemned the practice as dangerous.

Velpeau advised irrigation in encapsulated cavities. Boinet and Boudant recommended chlorides and iodides, and Sedillot, a caustic solution, as the therapeutic agent. Since that time a great variety of solutions have been used, such as methyl salicylate, phenol, creolin, iodine, saline solution, hydrogen peroxide, boric acid and carbolated iodine, corrosive sublimate, and "purefied air." After the use of intrapleural antiseptics

fell decidedly into disrepute, it was renewed again by J. B. Murphy, who was a staunch advocate of the use of formalin in glycerine.

In the available literature, the first mention of the use of chloride of lime was by de Brabant in 1837. Townsend in 1845 recommended a "weak solution of chloride of lime as an antiseptic."

Since the work of Dakin and Carrel with the hypochlorite solution, intrapleural injection has come into favor again. Its use, however, has been largely limited to acute cases.

GENERAL CONSIDERATION OF PRINCIPLES OF TREATMENT

From the foregoing historical review it is found that, although empyema has been recognized and treated for twenty-six centuries, it is only sixty years since a sound rib first was resected for drainage. During the next thirty years attention was directed solely toward collapsing the thoracic wall for obliteration of the cavity. The most radical stage was reached in the complete Schede resection. Since that time the trend has been toward increasing conservatism, the first real contributions in this direction being those of Delorme and Fowler. It has also become more clearly and generally recognized that there is a considerable variability in the pathologic and clinical aspects of the disease.

The first essential to a consideration of treatment is a clear conception of the cause of chronicity and of the pathology involved. Since chronic cavities and residual sinuses are often but different stages in the same case, the two conditions are considered together. It should be recognized, however, that each may exist independently.

The most common causes of persistent fistula, apart from chronic cavities, are osteomyelitis of the rib, bronchocutaneous fistula, extreme sclerosis of the walls of the sinus, foreign bodies, and, occasionally, tuberculosis. The common causes of a persistent cavity are inadequate drainage; pneumothorax, whether from early open drainage or from a ruptured subpleural abscess resulting in more or less complete collapse of the lung not yet fixed by adhesions; too late drainage after the lung has become fixed firmly in a collapsed position; persistent bronchial fistulas; the presence of foreign bodies; reinfection; and tuberculosis. Of all these factors insufficient drainage is the most common. As a result of the prolonged suppuration a pyogenic membrane which may be 1.25 cm. or more thick is formed. This membrane tends to prevent expansion of the lung even after the primary cause is removed. Treatment should naturally be designed, so far as possible, to remove the cause. Dependent drainage and removal of necrosed rib or foreign material are simple procedures, yet they often bring about a cure after years of chronicity. If a bronchial fistula is present its closure is usually a prerequisite to healing.

The pathologic condition often can be recognized only in part. Conditions of the lung with respect to tuberculous and other sclerotic changes

are often difficult to determine. If an extensive pulmonary tuberculosis is present, or if the bacilli are demonstrated in the pleural exudate, or the typical microscopic picture is found in the sectioned pleura, the diagnosis is established. A history of a primary pleurisy with serous effusion, later becoming purulent, is also at least very suggestive. Often, however, the history and findings are indefinite and uncertain. Primary tuberculous empyema, secondarily infected by injudicious drainage or from within, may present a typical picture of the ordinary suppurative pleurisy.

Whether or not the lung is capable of expansion is difficult to decide with any certainty. Various methods to ascertain this have been described, mostly based on a decrease in the size of the cavity during forced expiration. Obviously such a determination may be more a measure of the relative rigidity of the thickened pleura than the elasticity of the lung. Reineboth's ingenious method, depending on the changes in pulmonary circulation that result in increasing the intrapulmonary pressure in a lung that is still expansible but in which changes do not occur if expansibility is lost, unfortunately has not so far proved of practical value. The mechanism by which a collapsed lung expands is of much practical importance and the subject of much difference of opinion. The presence of an intrapleural pressure less than atmospheric and the reason for this so-called "negative" pressure is an elementary fact in physiology. It is also recognized that if an opening is made into the pleural cavity, the lung collaspses from equalization-pressure on the two sides of the lung alveolus. Other factors of the first importance to the clinical application of these fundamentals until recently have received but scant attention. Among such factors are the size of the opening in the chest wall in relation to the size of the glottis, the presence of adhesions between the lung and the chest wall, the mobility of the mediastinum, and the vital capacity. The importance of the relationship between the opening in the chest wall and the glottis was recognized by Houston. He asked van Swieten if a person wounded in both sides of the thorax would die. On being answered in the affirmative Houston produced a small normal dog on which he had opened both pleuras three days before. This astonished van Swieten, who repeated the experiment and was persuaded that when air entered the two pleural cavities the wounds were fatal only if the two openings combined were larger in area than that of the glottis. Later Cruveilhier repeated these experiments. It remained for Graham and Bell, however, to point out the great importance of the relationship to the treatment of acute empyema. They showed that in acute cases, owing to the mobility of the mediastinum, the two pleural cavities react as one to changed intrathoracic pressure. Lowering or neutralizing the negative pressure on the one side changed the pressure the same on the other side. Graham showed that the absolute size of an opening in the chest wall, compared with that of the glottis, depends on the vital capacity at

the time. Thus a man with healthy lungs can withstand a much larger opening than one with pneumonia or poorly developed lungs.

These considerations are of fundamental importance in the treatment of empyema. The large number of variables involved explains, at least in large measure, the apparently divergent experiences and opinions on the subject of acute pneumothorax. In chronic empyema, because of the fixation of the mediastinum and the presence of pulmonary adhesions, the two pleural cavities function independently. For this reason a wide opening on the affected side does not produce respiratory insufficiency.

The mechanism by means of which the lung reëxpands has been variously explained. Roser held that it was by the progressive growth of adhesions along the margins of the cavity, the contraction of which pulls out the lung. Weissgerber, on the other hand, held that lung expansion is due to increased intratracheal pressure during expiration, resulting in a summation expansion of the lung. The different conceptions are reflected in the variety of devices for increasing the intratracheal tension, on the one hand, and for decreasing the tension in the pleural cavity, on the other. More recent opinion is also divided. Physicians still use pleural suction. Perhaps the majority, however, are of the opinion that the lung, when free, expands essentially because of the increased tension from within the bronchi, during coughing, straining, or other effort involving closure of the glottis, and that closed drainage, valve action, a pus-soaked dressing, and the like are used chiefly in helping to hold the amount of expansion gained. There is much clinical evidence also indicating that progressive adhesions help to hold the lung out, once it is expanded.

Some surgeons believe that adhesions are always detrimental. Thus Lloyd, on the principle that the adhesions tend to prevent expansion, routinely separated them at operation. He reported cases of 225 patients treated in this manner, but with less than 50 per cent. complete cures and 20 per cent. mortality. Homans has expressed the belief that adhesions in the early stage are often the cause of chronicity, but that fixation of the lung to the diaphragm favors expansion.

In chronic empyema the greatly thickened membranes prevent the action of the mechanism which brings about expansion of the lung. If these membranes are removed, incised, or disintegrated, the same mechanism again comes into play, provided the lung has retained its elasticity.

At operation it is often observed that when the patient coughs or strains the liberated lung expands in response to the increased intratracheal pressure. In the after-treatment, as in the acute condition, the same factors favor permanent expansion. In the cases in which cavity obliteration occurs following the liberating action of Dakin's solution, it can be determined when operation is performed for a small residual cavity, that the lung is adhering progressively at the periphery of the cavity. Dunham observed at necropsy, in cases in which Dakin's solution was

used, that the walls of the cavity were covered with granulations favorable for adhesions, while in those in which there was no treatment a shaggy fibro-purulent deposit was found. In case of reinfection these adhesions tend to break down and the cavity enlarges.

Tuffier, Stevens, and others have reported series of cases in which, after sterilization, the tubes were withdrawn and the pneumothorax left to itself, but this method has resulted in many recurrences. If the treatment is successful, the lung apparently expands in proportion as the air absorbs, but in some instances cavities have persisted for months. It seems reasonable to believe that such treatment is more suitable in recent cases than when the condition has persisted for years. To what extent an increasing pulmonary circulation, incident to deep breathing exercise and other effort, aids in bringing about expansion, can not be stated, but some experimental evidence has been found to indicate that an increased circulation in the capillaries tends to expand the lung alveolus.

In cases of tuberculous empyema a large cavity may persist for years without any tendency toward lung expansion. At operation in some such cases it is found that the pleura is not appreciably thickened; the failure to expand is probably due to a fibrosis of the lung by which it has lost its expansibility. Fibrosis seems to occur also in long-standing pyogenic empyema.

Aside from considerations of etiology and pathology, the guiding principle in the choice of treatment should be conservatism. Chronic empyema is not necessarily incompatible with years of life and usefulness. In such cases it may be questioned whether radical treatment involving considerable loss of function is ever indicated. It would certainly seem difficult to justify a high mortality, particularly if a safer and more effective method is available. Shortening convalescence is often mentioned as one of the arguments for a radical procedure, but it seems that shortening convalescence does not justify an increased mortality. In the choice of a method of treatment the first consideration, therefore, should be the life of the patient, the second, the preserving of function, and the third, the shortening of the convalescence.

CLINICAL STUDY OF CASES AT THE MAYO CLINIC

In 49 of 150 cases of empyema at the Mayo Clinic prior to 1910 the Estlander operation was performed; in 9 the Schede resection, and in 1 the Delorme decortication. One death occurred following a Schede operation. The 210 patients with empyema treated between 1910 and November, 1917, had more or less extensive rib resections. A Schede operation was done in six instances, a decortication in seven, and Ransohoff's discission of the pleura in one. There were fourteen deaths; one followed a decortication.

During a little more than two years beginning November, 1917, 150 patients with chronic empyema have been treated in the clinic, with a few exceptions, by the writer. Eight of these patients had sinuses only,

some of which, however, were fairly extensive. The others had chronic cavities varying in capacity from 50 to 2500 c.c. One hundred and seventeen of the series had been operated on elsewhere. Most of the others came with large accumulations of pus, variously diagnosed. One boy presented himself for the treatment of an extreme scoliosis due to unrecognized empyema of probably eight years' duration. One had been given up as a hopeless case of malignant disease. Unresolved pneumonia and abscess of the lung were diagnosed in many of these cases. Fifteen had tuberculous empyema. Judging from the history, clinical findings, and course, thirteen others may also have been tuberculous. One case of actinomycotic empyema is not included.

It may be noted that three months are taken arbitrarily as the time limit between acute and chronic empyema. In some patients in the series, not previously operated on, the date of onset had to be approximated from the history. In many of the others, in which the duration was calculated from the date of a late operation, it was probably considerably longer than stated. The duration of the empyema by periods and the number of cases in each is indicated in Table I.

TABLE I

Duration of Empyema

	Cases
3 to 5 months	38
6 to 12 months	47
13 to 24 months	30
2 to 3 years	12
3 to 5 years	7
5 to 10 years	11
10 to 15 years	3
15 to 20 years	1
More than 20 years	1
	150

TABLE II

Age

	Patients
Less than 5 years	6
6 to 10 years	5
11 to 15 years	6
16 to 20 years	24
21 to 30 years	58
31 to 40 years	34
41 to 50 years	9
51 to 60 years	7
66 years	1
	150

Only eleven were children under ten, yet five of the unrecognized cases were in this age group. In one of these the diagnosis had been first diphtheria, then scarlet fever, and finally typhoid fever.

TABLE III

Occupation

	Cases
Farmer	54
Business man	23
Laborer	11
Housewife	9
Student	10
Carpenter	6
Machinist	5
Soldier	3
Miner	3
Railroad man	9
None	6
Not stated	2
Miscellaneous	9
	150

The occupation seemed to bear no obvious relation to incidence.

In nineteen cases there was a fairly definite family history of tuberculosis. Alcoholism in moderation was noted in thirty-seven, and in excess in three. A past history of pneumonia was given in 105, in several of which there had been more than one attack. Pleurisy had been present in association with pneumonia in sixty-four, and was primary in sixteen. A serous effusion followed pneumonia in two definitely tuberculous cases. In eight instances of primary effusion a definite diagnosis of tuberculosis could not be made, but several of these cases ran a clinical course characteristic of a tuberculous empyema secondarily infected.

TABLE IV

Chief Complaints

	Cases
Draining sinus	87
Pain in chest	22
Weakness	11
Fever	7
Cough	9
Abscess of lung	6
Œdema	4
Arthritis	4
	150

The history of onset was given as sudden in 108 cases, insidious in thirty-two, and not stated in ten. The etiologic factors stated in the history were as follows:

TABLE V

Etiologic Factors

	Cases
Pneumonia	65
Pleurisy	15
Influenza	38
Trauma	8
"Cold"	6
Not stated	7
Miscellaneous	11
	150

Pain was a definite symptom in sixty-five; it was localized in the thorax in fifty-seven, and in the joints in four, and associated with respiration in six. Marked weakness was noted in fifty-five; cough was present in seventy, absent in twenty-eight, not stated in thirty-two, and was associated with sputum in sixty. The sputum was profuse in eleven; 500 c.c. in three, and 1000 c.c. in two, these being cases of bronchial fistula. Dyspnœa and pallor were noted in thirty-six and weakness in fifty. Hæmoptysis was noted in four. Loss of weight was a fairly prominent symptom.

TABLE VI

Loss of Weight

	Cases
Less than 10 pounds	6
11 to 15 pounds	7
16 to 20 pounds	14
21 to 30 pounds	14
31 to 40 pounds	12
41 to 50 pounds	2
51 to 60 pounds	3
61 to 70 pounds	2
None	10
Amount not stated	34
No mention	46
	150

Fever was present in seventy-five cases, and associated with chills in twenty-two. There was a leucocytosis in two-thirds of the cases in which a count was recorded. The average counts were as follows:

TABLE VII

Leucocytosis

	Cases
10,000 to 12,500	28
12,500 to 15,000	17
15,000 to 20,000	20
20,000 to 25,000	14
25,000 to 30,000	5
30,000 to 40,000	2
None	45
Not stated	19
	150

A persistent high leucocyte count was frequently observed in the cases in which Dakin's solution treatment was used without fever or other symptoms of toxic absorption. A secondary anæmia was present in the majority of patients, and to a considerable degree in about a third. The averages in 126 were as follows:

TABLE VIII

Hæmoglobin

	Cases
40 to 50 per cent.	10
50 to 60 per cent.	30
60 to 70 per cent.	46
70 to 80 per cent.	36
80 to 90 per cent.	4

A low blood-pressure indicative of an asthenic condition was noted more often than a high pressure. No significant variation was found between systolic and diastolic pressures.

TABLE IX

Systolic Blood-pressure

	Cases
80 to 90	3
90 to 100	15
100 to 110	24
110 to 140	77
140 to 160	5
160 to 180	1
Not stated	25
	150

The urinalysis indicated only a relatively small number of cases with kidney involvement, even though the average duration was more than one year in sixty-five of the cases. On the basis of the terminology used in the Mayo Clinic, "albumin 1" signifies the slightest possible trace demonstrable. The albumin content was found to be as follows:

TABLE X

Albuminuria Graded 1 to 4

	Cases
Grade 1	66
Grade 2	25
Grade 3	1
Grade 4	1
None	43
Grade not stated	14
	150

Bacteriologic studies of the exudate at operation revealed the usual bacterial flora. Except for tuberculous infection, there appeared to be no clear relationship between the type of organism and the severity or course of the process in these chronic cases.

The right side was involved in eighty cases and the left side in seventy. The most constant physical signs aside from the presence of a sinus were dulness and flatness to percussion in varying proportion and degree. Dulness was noted in eighty-three and flatness in sixty-two.

Limitation of respiratory excursion was found in the majority of cases.

Fremitus was noted in the area involved in eight cases. Clubbing of the fingers was stated to be present in nineteen and clubbing of the toes in one. The heart was displaced to the right in fifteen and to the left in nine. A palpable liver and spleen, indicative of a degeneration, was noted in five and six cases, respectively.

The clinical diagnosis of the presence of empyema presented little difficulty. A typical empyema is most apt to be overlooked in children. Occasionally an encapsulated empyema with a large bronchial fistula may be quite difficult to distinguish from an abscess of the lung. In some cases, as in one of this series, both were present. In other cases in which there is a history of cough with large amounts of sputum, the differentiation may be impossible without X-ray. Three patients in this series with such symptoms had been treated for months for abscess of the lung. In one instance an empyema had persisted for years without breaking through either lung or chest wall. One case of typical empyema necessitas simulating an acute mastitis was observed. The clinical diagnosis supported by the X-ray examinations in this series was as follows:

TABLE XI

Clinical Diagnosis

	Cases
Chronic empyema	115
Effusion or empyema with tuberculosis	9
Empyema with pneumothorax	7
Empyema with bronchial fistula	8
Empyema or abscess	3
Pleural effusion	5
Pneumonia	1
Dermoid cyst	1
Echinococcus cyst	1
	150

It will be noted that a diagnosis of tuberculosis was made clinically in nine of the cases, but the tuberculous lesion was in the lung in five; a tuberculous effusion was specified in four. A diagnosis of a pulmonary lesion was made in three additional cases by the Röntgen-ray. One of these and two others were proved microscopically. All of these patients gave a history of pleurisy with effusion. Thirteen other patients gave a similar history of a primary pleurisy with effusion. Four of these patients were later proved to have a tuberculous infection of the pleura. Three who were shown by the röntgenogram to have pulmonary involvement clinically responded very well to treatment; the other two reacted in a manner characteristic of a tuberculous empyema. From these findings it appears that while both a pulmonary lesion and a history of a preceding pleurisy with effusion are important in the differential diagnosis of a tuberculous empyema, a pleurisy with effusion is probably the more significant. A tuberculous empyema may run its course without any clinical or Röntgen findings to suggest the condition (Fig. 1).

The choice of surgical treatment for chronic empyema has been between simple drainage and some type of operation designed to collapse the chest wall or to expand the lung. In the earlier cases in this series, if a cavity of any size persisted, simple drainage was first tried, followed by a decortication. In the autumn of 1918, Dakin's solution was first used in an attempt to obtain partial sterilization of the cavity before a decortication or plastic operation was performed. It was then discovered that not only the patient's general condition was improved greatly, but the cavity showed an unmistakable tendency to reduce. The solution was then used systematically and an extensive operation performed only after the hypochlorite solution treatment had been tried. If operation was indicated for a cavity of considerable size in a non-tuberculous case, an attempt was made routinely to obtain expansion of the lung before a collapse operation was performed.

Methods of Treatment.—The methods of treatment were as follows: (1) Simple rib resection, forty-two cases; (2) Dakin's solution with or without minor drainage operations, fifty-one cases; (3) pulmonary decortication, thirty cases; and (4) plastic operation on the chest wall, twenty-seven cases.

1. *Simple Rib Resection.*—Thirty-four of the forty-two patients in this group had been operated on elsewhere. Many of them had undergone several, and one eleven drainage operations. Among those who had not had previous operations there were several with large cavities. Two had bronchial fistulæ and were emptying the contents of a large cavity through the bronchus. Two had drainage tubes in the pleural cavity, the presence of which had been unsuspected. Faulty drainage was the rule; the drainage opening had been allowed to close or narrow down to a sinus before the cavity had become obliterated, or the opening was not at the most dependent point. The capacity of the cavity in this group was less than 250 c.c. in twelve, between 250 and 500 c.c. in eight, and near 1000 c.c. in two; in one the lung was almost wholly collapsed.

The results of simple drainage operation, not counting the tuberculous cases, were: Complete recovery, twenty-six cases; persistent sinus at last report, four cases; and death, one case. Eight patients could not be traced. Of the tuberculous patients one was greatly improved, one somewhat improved, and one was not benefited. All three had been drained previously elsewhere.

2. *Dakin's Solution With or Without a Minor Drainage Operation for a Small Residual Cavity.*—There were fifty-one cases in this group. The technic employed consisted in the insertion of a catheter through the old sinus or through a trocar and cannula, aspirating the pus and irrigating with the sodium hypochlorite solution. As a rule, normal saline solution was used for the first irrigation, and if there had been cough with sputum it was used always in order to avoid the marked bronchial irritation if a bronchial fistula should be present. Irrigation was performed at intervals of from one to three hours. Once or twice each day the cavity was half filled with the solution, which was aspirated after about ten minutes. Once a week the cavity was filled by gravity and the capacity noted. In this way progress was measured. The patients were encouraged to use blow bottles and other devices to produce increased intratracheal pressure. While they were blowing the catheter was connected with a tube, the other end of which was under water in order to allow the air to escape as the lung expanded and to prevent its return. The patients were given setting-up exercises and encouraged to be outdoors as much as possible besides. A generous diet was prescribed.

TABLE XII

Results of Dakin's Solution Treatment in Fifty-one Cases

Capacity of cavity	Average number of days of treatment	Capacity of cavity at end of treatment	Average decrease in capacity of cavity per cent.	Cases
Less than 100 c.c.	35.9	10 c.c.	90.0	11
100 to 250 c.c.	34.1	11 c.c. to 27.5 c.c.	89.0	16
250 to 500 c.c.	56.4	11 c.c. to 22.0 c.c.	95.6	15
500 to 1000 c.c.	45.2	11 c.c. to 22.0 c.c.	97.8	5
1000 to 2000 c.c.	32.0	80 c.c. to 160 c.c.	92.0	4

	Cases
Complete recovery	34
Sinus at last report	6
No late report	6
Convalescence not completed	4
No benefit (tuberculosis)	1
	51

A large portion of the time spent in treatment was for the final obliteration of a cavity after it had been reduced 50 to 75 per cent. (Figs. 2 and 3).

Besides the reduction in the size of cavities of more than 90 per cent., there was a striking general improvement in all these patients. A gain in weight of from 1 to 2 pounds each day for a period of two or three weeks was frequently observed. A slight amount of bleeding and occasionally some cough were noted, but no serious complications. The hypochlorite solution was used in fifteen patients preliminary to pulmonary decortication. Six were treated for a period not exceeding three weeks, all of these showing an appreciable decrease in the size of the cavity. In the other cases, with one exception, there was also a material decrease (Figs. 4 to 12).

TABLE XIII

Result of Dakin's Solution Treatment Preliminary to Decortication in Fifteen Cases

Capacity of cavity	Duration of empyema, months	Days of treatment	Capacity of cavity at end of treatment
360 c.c.	6	9	210 c.c.
500 c.c.	20	10	200 c.c.
200 c.c.	21	12	100 c.c.
500 c.c.	6	12	180 c.c.
240 c.c.	4	19	150 c.c.
300 c.c.	4	21	240 c.c.
150 c.c.	3	27	150 c.c.
420 c.c.	15	30	390 c.c.
1000 c.c.	14	32	90 c.c.
150 c.c.	7	42	15 c.c.
1500 c.c.	3	43	100 c.c.
400 c.c.	4	46	30 c.c.
500 c.c.	6	70	60 c.c.
2000 c.c.	6	75	120 c.c.
2000 c.c.	14	150	240 c.c.

Several of the patients in this series would not have withstood an operation of any magnitude without the preliminary treatment. One was a girl with complete collapse of the lung following traumatic empyema. She was reduced from 120 pounds to 73 pounds and was brought to the clinic on a stretcher. She was completely cured with almost full re-expansion of the lung. Another patient had an almost total pneumothorax, a complete inhibition Wassermann reaction, and a severe grade of nephritis with œdema. His blood was rendered negative to the Wassermann test, his lung reëxpanded about 90 per cent., and he gained about 30 pounds as a result of the preliminary treatment.

3. *Pulmonary Decortication.*—There were thirty cases in this group. The operation, except in some early cases before Dakin's solution was employed as a routine, was performed only after the antiseptic method had been used and a large cavity remained. In a few of the early cases, only, the cavity was comparatively small. In these cases in which it failed to obliterate, it had been rendered relatively sterile, and the patient's general condition was very materially improved.

Decortication was done under general anæsthesia through a rib-spreading exposure. By use of a suitable rib retractor, adequate exposure was obtained without cutting the ribs. In some cases in which the cavity lay very high, incision was made in the sixth or fifth interspace, cutting the scapula across and resuturing it. Possibly resection of the ribs posteriorly would have been a better procedure. The thickened visceral pleura was incised and separated by blunt dissection. In many cases the preliminary irrigation had softened it to such an extent that the separation could be done very readily. If cavities were large a complete visceral decortication was done, mobilizing the entire lung. In one case only, of primary tuberculous empyema, it was absolutely impossible to separate or satisfactorily to incise it, but partial obliteration of the cavity was secured by mobilizing the lung, as first suggested by Souligoux.

TABLE XIV

Results of Decortication in Thirty Cases

	Cases
Complete cure without further surgery	15
Complete cure after secondary plastic operation for small residual cavity	5
Persistent sinus, last report	3
Death following operation	1
Death from other causes several weeks after patient left hospital	3
Under treatment	3

Two of the three patients with small sinuses were tuberculous. In

one of these the cavity was practically obliterated. The patient gained very materially in weight and general condition following operation. The one operative death was due to a streptococcus pneumonia occurring during an influenza epidemic. Two of the patients who died several weeks

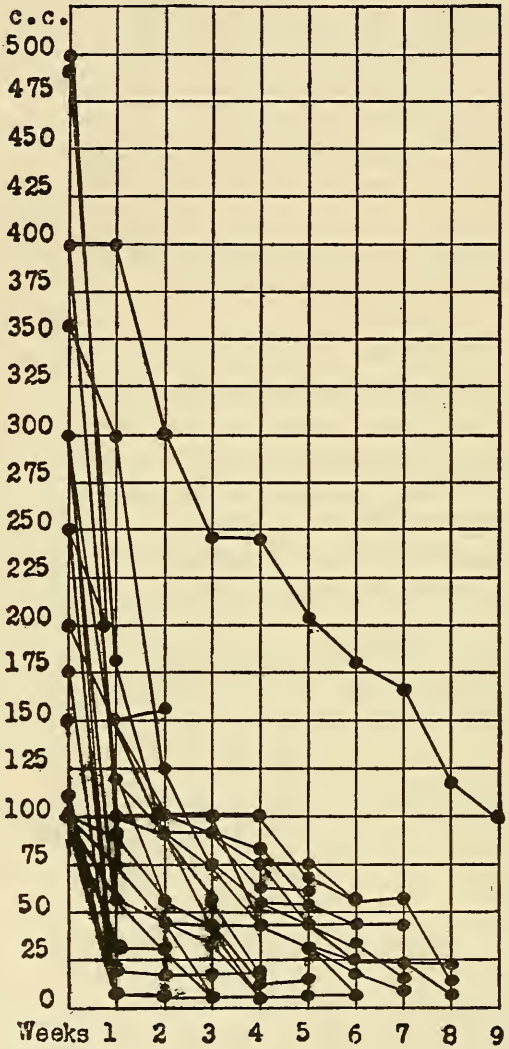

FIG. 2.—Twenty-eight cases, capacity from 100 to 500 c.c.

after operation also had epidemic influenzal bronchopneumonia. Necropsy in one of these showed one lung expanded and an empyema on the other side. The third patient, in whom the cavity had been reduced to about 30 c.c. capacity by operation, died of pulmonary hemorrhage seven months later. Tuberculosis bacilli were found in the exudate and tubercles in

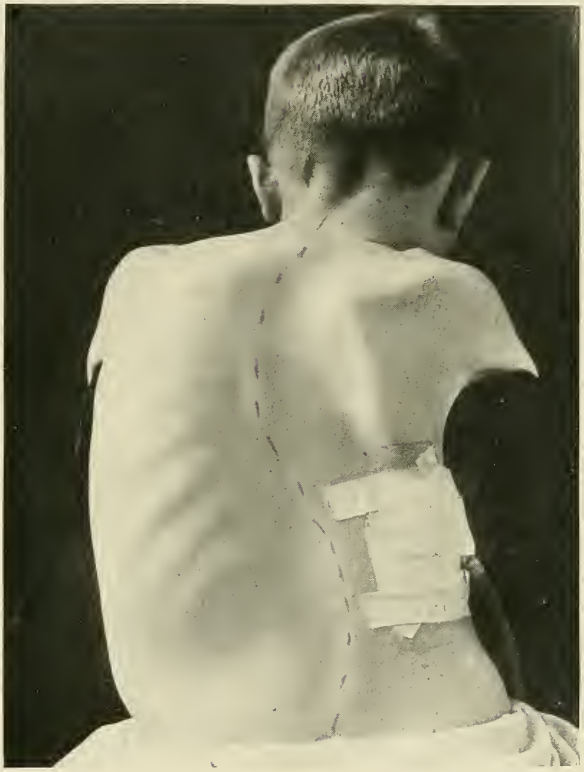

FIG. 1. (Case 269926).—Unrecognized empyema probably of eight years' duration; cavity obliterated by Dakin's solution and minor drainage operation.

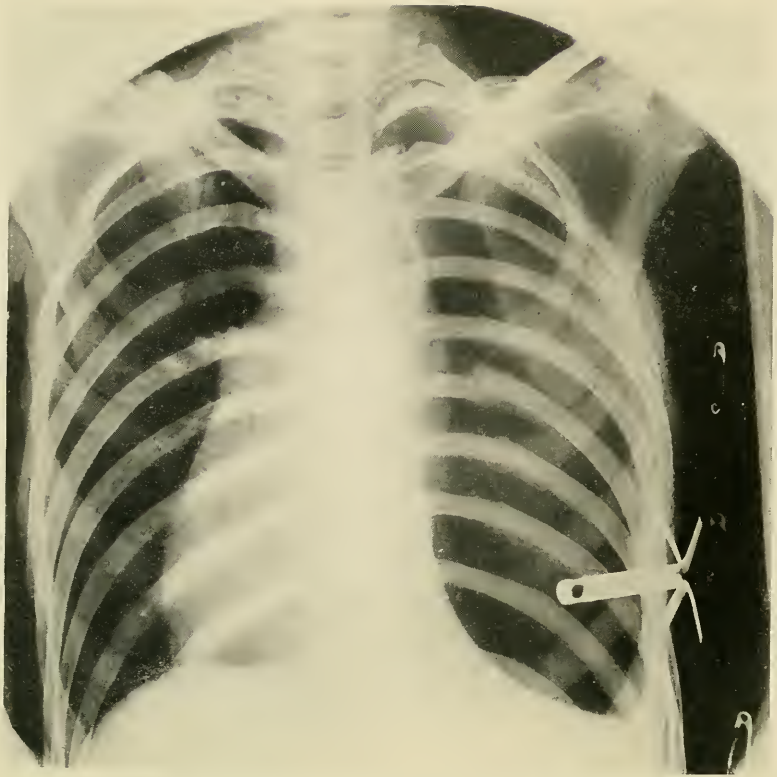

FIG. 4 (Case 261485).—Traumatic empyema of four months' standing; fracture of ribs; almost complete collapse of the lung before Dakin's solution treatment. Patient's weight, 73 pounds; normal weight, 125.

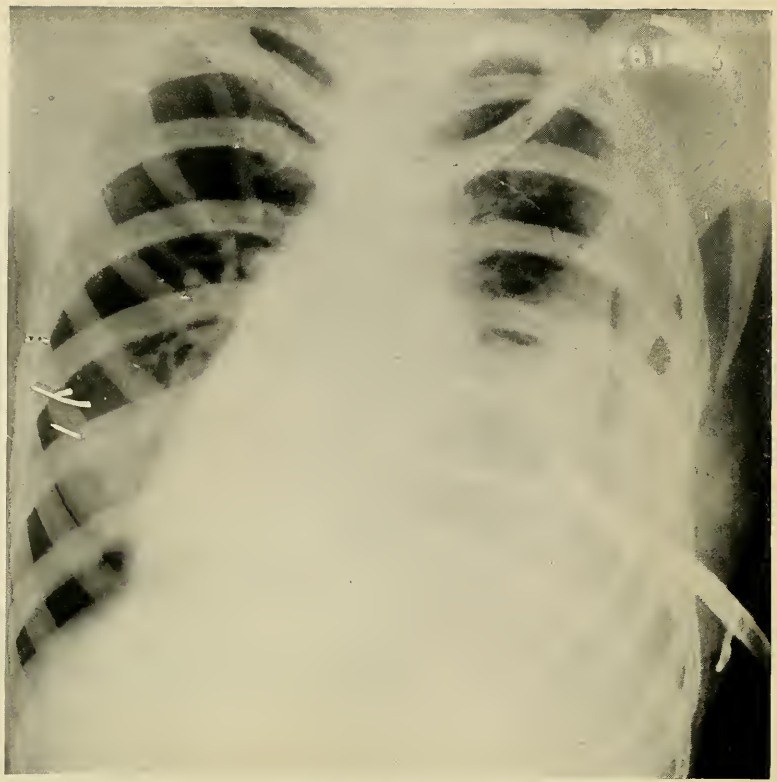

FIG. 5 (Case 261485).—Full expansion of the lung at the apex of empyema cavity shown in Figs. 4 and 5 after about four months' treatment. Complete cure followed plastic operation on residual cavity.

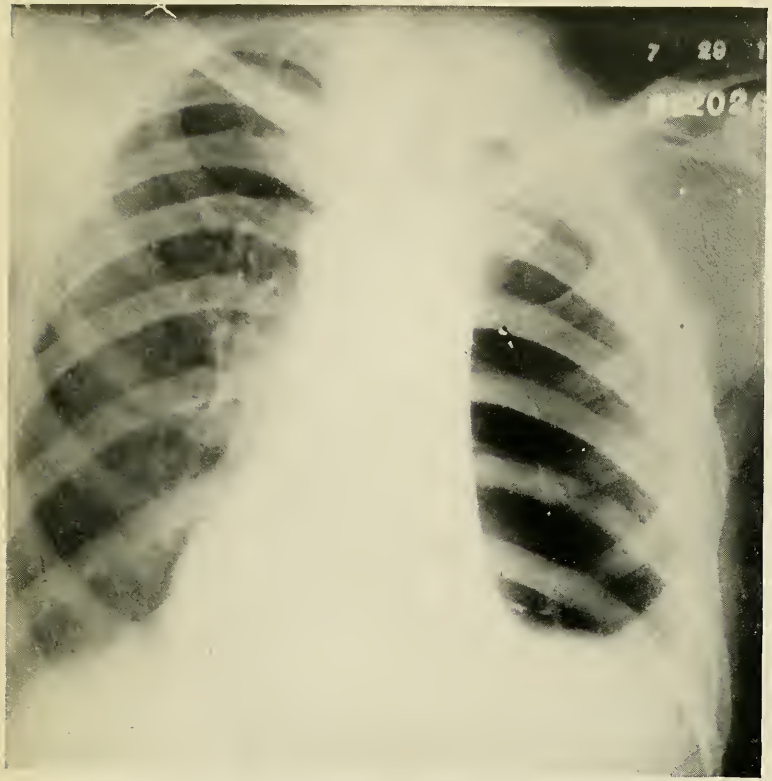

FIG. 6 (Case 282026).—Chronic empyema of eighteen months' duration; with massive collapse of lung; chronic nephritis with œdema, and complete inhibition Wassermann test.

FIG. 7 (Case 282026).—Lung shown in Fig. 6 partly expanded; Wassermann negative, and patient gained 30 pounds in weight.

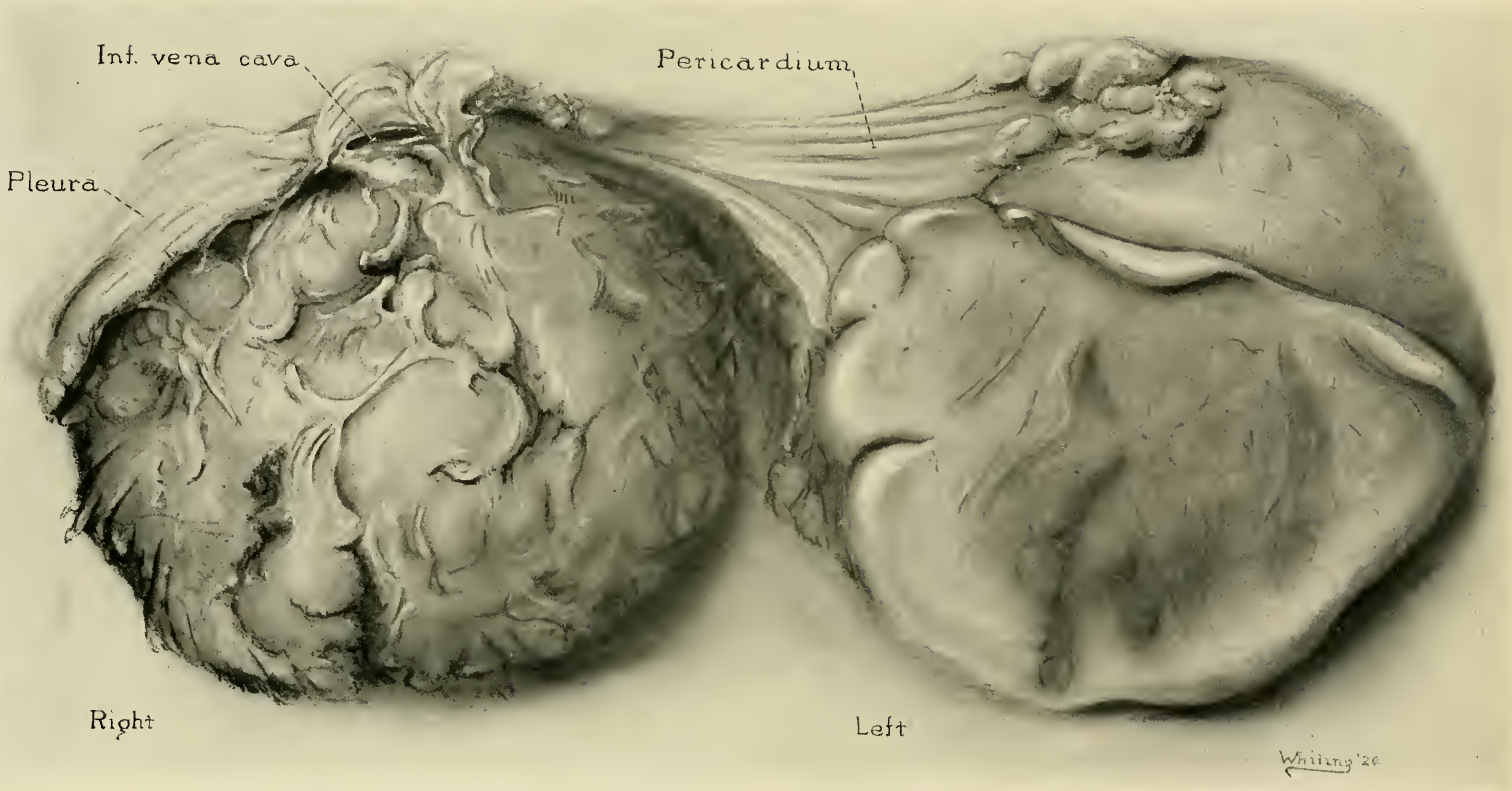

FIG. 8 (Case 307155).—Partial expansion of lung following decortication for empyema, after complete collapse of sixteen months.

the pleura shortly before death. At no time did the X-ray show any evidence of tuberculosis (Figs. 13 to 17).

4. *Plastic Operation Involving the Collapse of the Chest Wall.*—Twenty-seven patients were treated by this method. The duration of the disease

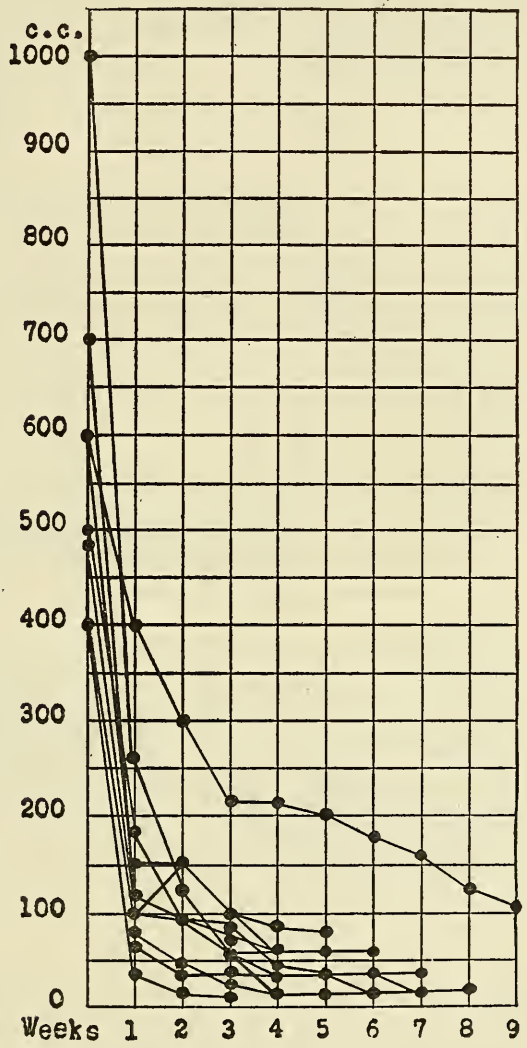

FIG. 3.—Ten cases, capacity from 400 to 1000 c.c.

was more than one year in twenty-one and more than two years in eleven; in one it was of twenty-three years' duration. Five patients were definitely proved to be tuberculous; two others belonged to the group of primary pleurisy with effusion which ran a course suggestive of tuberculosis. Dakin's solution was used in eight patients in this group (Fig. 18).

TABLE XV

Results of Dakin's Solution Treatment Preliminary to Plastic Operation in Eight Cases

Capacity of cavity	Duration of empyema	Days	Capacity of cavity at end of treatment
500 c.c.	3 months	22	120 c.c.
150 c.c.	4 months	55	30 c.c.
60 c.c.	3 years	57	45 c.c.
100 c.c.	3 years	35	100 c.c.
200 c.c.	10 months	30	60 c.c.
150 c.c.	1 year	9	150 c.c.
500 c.c.	9 months	47	30 c.c.
750 c.c.	7 years	90	300 c.c.

In nineteen cases the solution could not be used on account of fistulas, or they were early cases treated before the solution was used routinely.

The operation involved resection of the ribs over the entire cavity, and with one exception, in which an Estlander operation was performed, excising the intercostal tissue and parietal pleura. A complete Schede operation was not found necessary in any case. The extent of rib resection was reduced in the majority of cases by the skin sliding method described by Beck. In a few instances a skin-muscle flap, as recommended by Robinson, was made. Resection of the lower angle of the scapula was necessary in three instances in which the cavity lay directly under it. In one case of tuberculous empyema of twenty-three years' standing, the whole chest wall was resected *en masse,* after the method recently described by Peuckert. In another, also tuberculous, the Wilms operation was performed in three stages.

TABLE XVI

Results Following Plastic Operation in Twenty-seven Cases

	Cases
Cure	15
Residual sinus at last report	3
Death	2
Convalescence not complete	4
Not traced	3
	27

Two of the patients with persistent sinuses were tuberculous. In one the sinus closed after many months. In one the sinus was due to multiple bronchial fistulas with an associated bronchiectasis. The closure of bronchial fistulas, as I have mentioned, is necessary to the cure of an empyema cavity.

The cases of bronchial fistulæ in this series may, for convenience, be divided into three groups; namely, those in which the fistulæ closed spontaneously, those in which it was obliterated by operative procedure, and those in which it persisted.

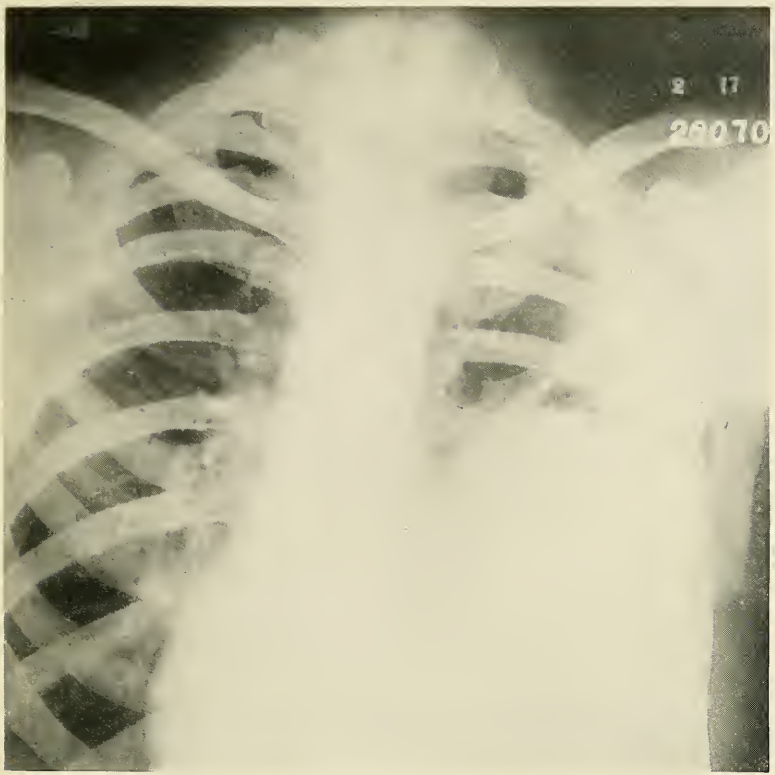

FIG. 9 (Case 260701).—Chronic empyema of four months' standing before treatment.

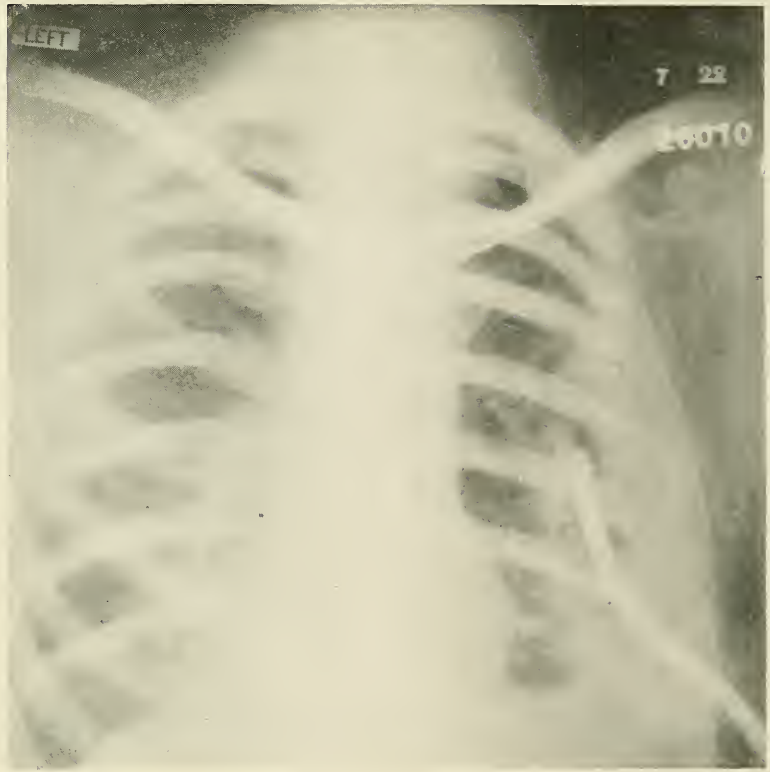

FIG. 10 (Case 260701).—Residual sinus of chronic empyema (Figs. 18 and 19) about nine weeks after decortication. Later cure was complete.

FIG. 11 (Case 185290).—Tuberculous empyema; partial obliteration of the cavity by the use of Dakin's solution treatment.

FIG. 12 (Case 185290).—Tuberculous empyema following Wilms' operation for obliteration of residual cavity.

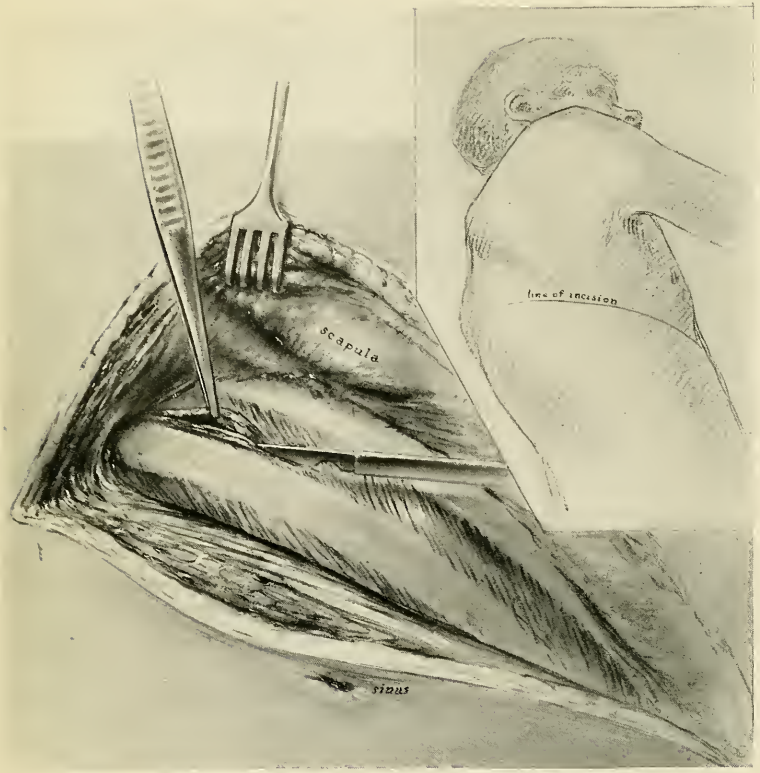

FIG. 13.—Intercostal incision for exploration of chronic empyema cavity.

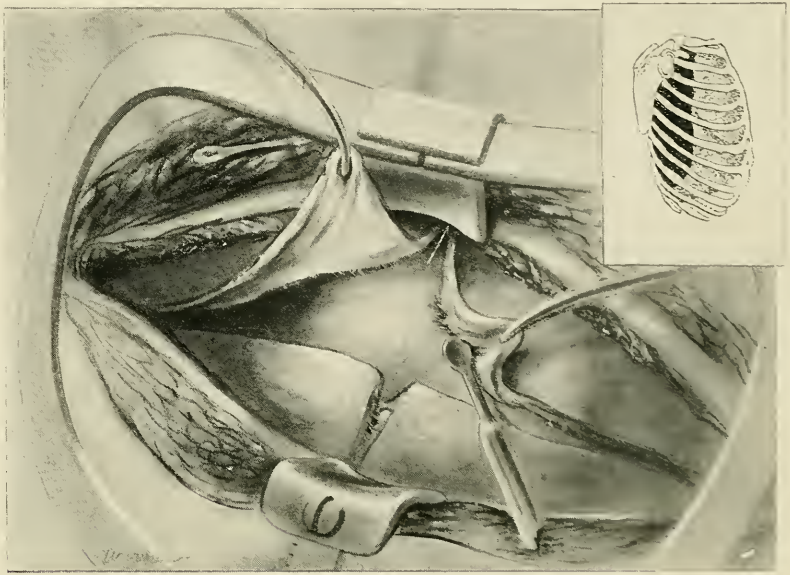

FIG. 14.—Decortication following a crucial incision in the pleura in a case of large cavity. The apex of the scapula has been removed, the ribs being divided in the sixth interspace. Retractor devised by the writer.

FIG. 15.—Lung expanding with straining of the patient.

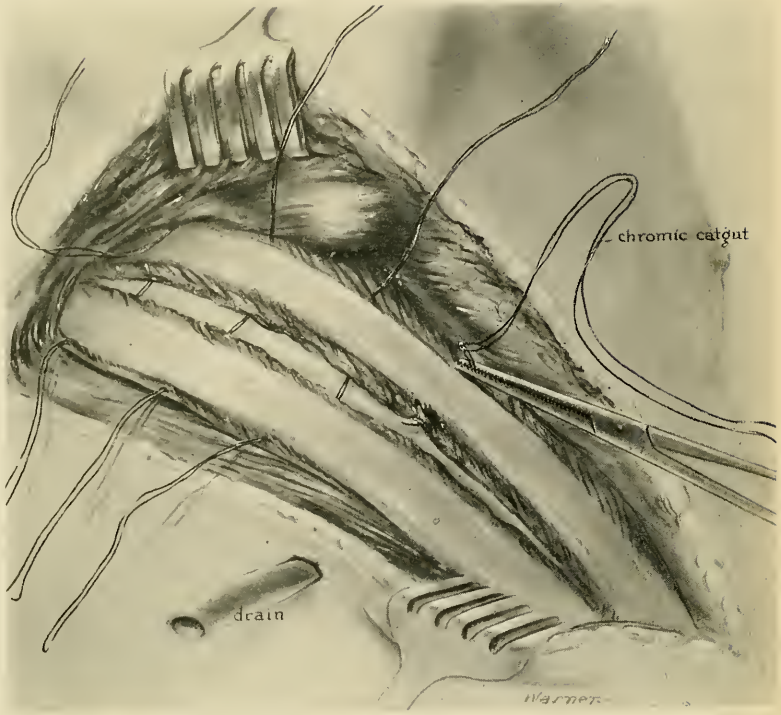

FIG. 16.—Air-tight closure of chest wall. Catheter through old sinus or through stab wound for aspiration and suction.

FIG. 17 (Case 251963).—Primary union following intercostal incision for pulmonary decortication. All ribs intact. The patient has free use of her arm.

FIG. 18 (Case 214734).—Plastic operation for closure of the chronic cavity.

FIG. 19.—Multiple bronchial fistulas in a patient with chronic empyema with bronchiectasis.

In the first group are a number of cases in which the hypochlorite solution was used. A bronchial fistula was judged to be present if the patient coughed during irrigation and at the same time tasted the solution. In some instances these symptoms were so slight and transitory that the treatment could be continued provided the cavity was not filled. In others irrigation could be done only when the patient assumed a certain posture. Occasionally it was necessary to substitute saline solution for longer or shorter periods. In a considerable number there was slight bleeding from time to time. In no case was the bleeding profuse. In a few the fistulas were observed at operation; they were uniformly small.

In the second group are the ten cases in which the fistulas were 0.7 cm. or more in diameter. They were multiple in one case only. Four were due to perforation of large unrecognized empyemas of long standing. These closed after wide open drainage was provided. In one case of ten years' duration a large fistula was found at the costovertebral angle. It was closed by an extensive resection and cauterization of the tract. In another instance the scar tissue was completely removed and the edges of the fistula sutured after preliminary cauterization. The remaining four fistulas were closed by resection of the ribs and thickened pleura followed by skin plastic.

In the group of cases with persistent bronchial fistulas were two tuberculous cases. In one an unsuccessful partial plastic operation was done; in the other no treatment was given for the fistula. A third patient had twenty or more bronchial fistulas in the same lobe of the lung, with extensive bronchiectasis. Considerable improvement in the general condition and obliteration of most of the fistulas resulted from granulation tissue proliferation after cauterization (Fig. 19).

RESULTS OF ALL METHODS OF TREATMENT

TABLE XVII

Summary of Results of Treatment in 150 Cases of Chronic Empyema

	Drainage operation	Dakin's solution treatment	Decortication operation	Plastic operation	Total
	Cases	Cases	Cases	Cases	Cases
Complete recovery	26	34	20	15	95
Residual sinus at last report	6	6	6	3	21
No report, or convalescence not completed	8	10	3	7	28
No relief	1	1	0	0	2
Death *	1	0	1	2	4
Total	42	51	30	27	150

Some of the persistent sinuses followed plastic operations for tuber-

* Besides the patients whose deaths were recorded as operative, four patients died after leaving the hospital, two several weeks after operation of streptococcus pneumonia; one died seven months after operation of tuberculosis, and one of "meningitis."

culous empyema, others are in recent pyogenic cases giving promise of complete closure. Practically all non-tuberculous sinuses can be obliterated by plastic operation. Since, as experience has shown, however, that the majority of the sinuses heal spontaneously, expectant treatment for a limited period has been considered justified and in many cases advisable.

TABLE XVIII

Operative Deaths

Cause of death	Operation	Cases
Sepsis and inanition	Rib resection for drainage	1
Cerebral abscess	Plastic operation	1
Tuberculous meningitis	Plastic operation	1
Influenzal pneumonia	Decortication operation	1
		4

CONCLUSIONS

From the study of the literature and of 150 cases from the Mayo Clinic, the following tentative conclusions may be drawn:

1. Chronic empyema has been recognized and treated during twenty-six centuries, but it is only sixty years since the first rib resection for drainage was done. The successive stages in the progress of treatment since that time are as follows:

(*a*) Increasingly radical treatment, designed to obliterate the cavity by the collapse of the chest wall, involving successively more extensive operations, and culminating finally in a complete radical resection.

(*b*) A conservative trend manifested primarily in the modifications of the complete resection, but more in the attempt to preserve the chest wall and to restore the lung to its structural and functional relationships as first advocated by Delorme.

(*c*) The adaptation of the Carrel-Dakin hypochlorite solution technic to the treatment of chronic empyema cavities.

2. Chronic empyema is a disease which is not incompatible with life nor with a fair degree of health and usefulness. The principles of treatment should, therefore, be, first, the preservation of life, and second, as far as possible, the conservation of function. Shortening convalescence, while very desirable, should always be a subsidiary consideration.

3. The choice of treatment must be made with cognizance of the variable etiology and pathology of the process, and the general condition of the patient.

4. A major procedure is indicated only if non-operative or less extensive surgical treatment reasonably may be considered less effective.

5. In case of sinuses and small cavities, adequate drainage is usually sufficient to effect a cure with or without short preliminary hypochlorite solution treatment. It is at least open to question whether a radical

operation is indicated in these cases for the sole purpose of shortening convalescence at the risk of an appreciably increased mortality.

6. Dakin's hypochlorite solution treatment is the method of choice in the treatment of the ordinary type of chronic empyema cavity of any size, for the following reasons:

(*a*) The general condition of the patient is, as a rule, improved to a remarkable degree.

(*b*) The cavity may be obliterated or greatly reduced in capacity by the liberation and expansion of the lung (resulting from the treatment).

(*c*) If the lung expands in part the extent of a later operation will be proportionately reduced.

(*d*) If the lung entirely fails to expand, the cavity will have become relatively sterile in preparation for operation, thereby lowering post-operative morbidity and mortality.

(*e*) Pulmonary decortication will be materially facilitated in some cases, owing to the softening action of the solution on the visceral pleura.

7. A pulmonary decortication through a rib-spreading exposure after preliminary hypochlorite solution irrigation is the most conservative treatment for cavities that are not obliterated by drainage or Dakin's solution treatment alone. If such an operation is successful, the lung is restored to its normal structural and functional relationship, thereby obliterating the cavity. If the operation is only partly successful, the magnitude of a secondary destructive operation is proportionately decreased.

8. Since it is impossible to judge with certainty before operation of the relative expansibility of the lung in every recent non-tuberculous case, a decortication should be done rather than a destructive operation, thereby giving the patient the benefit of the doubt.

9. If the lung does not expand, or if a considerable cavity persists following decortication, a plastic operation is indicated.

10. If the cavity is of considerable extent or the patient debilitated, a two- or three-stage plastic operation is to be recommended.

11. The recognition of tuberculous empyema is often difficult. A history of a primary pleurisy with effusion seems more often to signify a tuberculous condition than does a pulmonary lesion, unless the latter is active and extensive. A tuberculous empyema may be present in the absence of clinical or X-ray evidence of pulmonary involvement. The typical microscopic picture in the sectioned pleura or the demonstration of the bacilli in the exudate may constitute the only evidence in such cases.

12. A tuberculous empyema not secondarily infected should not be drained, and should be aspirated only for a considerable accumulation of fluid. For a tuberculous empyema secondarily infected, either by operation or spontaneously, drainage is necessary.

13. In the absence of bronchial fistulas and of bleeding, secondarily infected tuberculous empyema may be markedly benefited by antiseptic solution treatment. The amount of fibrosis or other pathologic change

in the lung in such cases determines the degree of expansion of the lung, whether following antiseptic solution treatment or decortication.

14. If the lung fails to expand in whole or in large part, a several-stage operation designed to collapse the chest wall is indicated. Tuberculous patients are relatively poor operative risks.

15. Adequate drainage is the first indication in cases of empyema cavities which are draining through large bronchial fistulas. The fistulas may be obliterated spontaneously following such treatment.

16. Operative closure of bronchial fistulas that persist is necessary to complete healing. It may be accomplished by decortication of the involved portion of the lung with cautery, suture, or skin plastic to cover the opening of the fistula. Occasionally healing results from simple granulation of surrounding tissue after destruction of the epithelial lining of the bronchial stoma.

17. Closing the bronchus that is draining pus from within the lung may result in a secondary lung abscess.

18. A large bronchial fistula is a contraindication to Dakin's solution treatment.

19. Sinuses of variable duration are common following more or less complete obliteration of empyema cavities; a large proportion eventually are obliterated without radical treatment; for those which persist, plastic operation is indicated.

20. Operative mortality in chronic empyema has been due largely to shock and infection. Reduction of the extent of operation and preliminary sterilization will materially lower this mortality.

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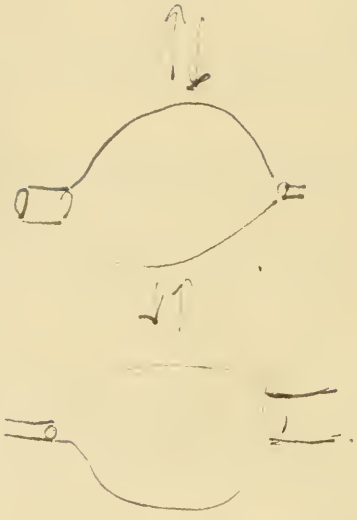

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